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Request for grant of a patent

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1. Your reference	P31562-/MHR/CCI/GEM	
2. Patent application number *(The Patent Office will fill in this part)*	12 AUG 2002	0218674.0
3. Full name, address and postcode of the or of each applicant *(underline all surnames)*	Mr Andrew J Boulton 5 Clarendon Road Linlithgow Lothian EH49 6AN	
Patents ADP number *(if you know it)*		7759040001
If the applicant is a corporate body, give the country/state of its incorporation		
4. Title of the invention	"Improvements in or Relating to Internal Combustion Engines"	
5. Name of your agent *(if you have one)*	Murgitroyd & Company	
"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	Scotland House 165-169 Scotland Street Glasgow G5 8PL	
Patents ADP number *(if you know it)*	1198015	

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7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application	Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:* *a) any applicant named in part 3 is not an inventor, or* *b) there is an inventor who is not named as an applicant, or* *c) any named applicant is a corporate body.* *See note (d))*	No

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11. I/We request the grant of a patent on the basis of this application.

Signature Murgitroyd & Company
Murgitroyd & Company

Date 12 August 2002

12. Name and daytime telephone number of person to contact in the United Kingdom

Edward Murgitroyd 0141 307 8400

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Improvements in or Relating to Internal Combustion Engines

This invention relates to improvements in or relating to internal combustion engines, and in particular, but not exclusively, to improvements relating to replacement apparatus for the intake and exhaust valves of internal combustion engines.

Conventional four stroke internal combustion engines involve a four stage cycle. Firstly, there is an intake of air/fuel mixture into a cylinder; known as "intake stroke". Secondly, a piston within the cylinder compresses the air/fuel mixture; known as "compression stroke". Thirdly, the compressed air/fuel mixture is ignited in the cylinder causing combustion; known as "combustion stroke". And lastly, the combusted gases are exhausted; known as "exhaust stroke".

A four stroke internal combustion engine comprises an intake valve to allow an ingress of air/fuel

mixture into a cylinder, and an exhaust valve, to allow an egress of exhausted gases after combustion of the air/fuel mixture.

The timing of the opening and closing of the valves is vital to an engines performance.

To allow the piston to draw-in the fuel/air mixture, the intake valve needs to open as the piston moves from an extended position to a retracted position on the intake stroke.

The exhaust valve needs to be opened as the piston is extended in the exhaust stroke.

Both the intake and the exhaust valves each comprise a rocker arm and a valve return spring, with the rocker arm being actuated by a cam or a lobe located on a camshaft.

The valves act against the valve return springs, where the valves are fired in one direction, only then to stop at the extent of their travel, and be sent flying in the opposite direction. This happens many times a minute which wastefully drains power from the engine. This also causes noise, vibration and harshness.

As the camshaft rotates, the shape of the cam which actuates the rocker arm, determines the timing of the opening and closing of the intake and exhaust valves.

Conventional designs of cams, particularly fixed cams, will only operate optimally for a given range of speeds.

According to an aspect of the present invention there is provided a cylinder head assembly comprising a cylinder head having an inlet passage and an outlet passage to and from a cylinder, and at least one rotatably mounted shaft member interposed between the inlet and outlet passages and the cylinder, the shaft member having a recess to allow an ingress of air/fuel mixture from the inlet passage to the cylinder at a first desired rotational position, and to allow an egress of combusted gases from the cylinder through the outlet passage at a second desired rotational position and to prevent the air/fuel mixture or combusted gases from entering or exiting the cylinder at a third desired rotational position.

Preferably, the shaft member is substantially solid.

Alternatively, the shaft member may be hollow.

Preferably, there is one shaft member interposed between the inlet and outlet passages and the cylinder.

Alternatively, there may be two shaft members; one for the ingress of air/fuel mixture and having one recess, and the other for the egress of combusted gases and having one recess.

Preferably, the shaft member(s) may be extended over a number of cylinders, the shaft member(s) having a corresponding number of recesses.

Preferably, the shaft member(s) have gas tight seal assemblies.

According to a further aspect of the present invention there is provided a cylinder head assembly comprising a cylinder head having a hollow inlet shaft member and outlet shaft member rotatably mounted; each shaft member having at least one aperture located around a portion of its circumference, wherein the inlet shaft member allows an ingress of air/fuel mixture from the inlet shaft member to enter said cylinder when the aperture in the inlet shaft is presented to the cylinder, and the outlet shaft member allows an egress of combusted gases to exit the cylinder when the aperture in the outlet shaft member is presented to the cylinder.

Preferably, the inlet and outlet shaft members may be extended over a number of cylinders, the inlet and outlet shaft members having a corresponding number of recesses.

Preferably, the inlet and outlet shaft members have gas tight seal assemblies.

Preferably, each shaft member comprises an inner hollow tube member rotatably mounted within the

hollow inlet and outlet shaft members which are also rotatably mounted; each inner tube member having at least one aperture located around a portion of its circumference; rotation of said inner tube member within the hollow inlet and outlet shaft members respectively provides a variable size effective aperture, which allows a variable ingress of air/fuel to enter said cylinder through the effective aperture in the inlet shaft member, and allows a variable egress of combusted gases from the cylinder to exit through the effective aperture in the outlet shaft member.

Preferably, the speed of rotation of the inner and outer tube members are such that the effective aperture maximises or restricts the rate of ingress of air/fuel mixture, or egress of exhaust gases, through the respective inner tube members.

Preferably, the inner tube members are coupled to a crankshaft with means for independently controlling or adjusting the speed of rotation of said tube members.

Alternatively, the tube members may be independently driven from the crankshaft, and from each other, with means for individually controlling or adjusting the speed of rotation of said tube members.

Preferably, the shaft members may be extended over a number of cylinders, the shaft members and inner tube members having a corresponding number of

apertures.

Preferably, the shaft members have gas tight seal assemblies.

According to yet still a further aspect of the present invention there is provided a method of allowing an ingress and egress of an air/fuel mixture and combusted gases from a cylinder comprising the steps of:

presenting a recess within a shaft member to an inlet passage;

retraction of a piston within a cylinder to allow an in-take of air/fuel mixture from the inlet passage into the shaft member;

the shaft member rotating to prevent any leakage of air/fuel mixture upon a compression of the air/fuel mixture in the cylinder by the piston;

combustion of air/fuel mixture causing said piston to retract;

the shaft member rotating further, continuing to prevent any leakage of resultant combusted gases;

piston extending in the cylinder;

the shaft member rotating to present the recess to the cylinder and an outlet passage to allow an egress of combusted gases; and

repetition of the above steps.

Preferably, the recess is an aperture in a hollow shaft and the method further includes the step of varying the effective aperture to restrict or maximise the amount of fluid flow through the aperture.

Embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings in which:-

Fig. 1 is a schematic front sectional view of a conventional four stroke internal combustion engine;
Figs. 2a-d are schematic front sectional views illustrating the workings of a single rotatably mounted shaft member of the present invention;

Figs. 3a-d are schematic front sectional views illustrating the workings of an alternative embodiment with two rotatably mounted shaft members;

Figs. 4a and 4b are a side view and perspective side view respectively (shown schematically) of an alternative shaft member;

Fig. 5 is a schematic plan view of further alternative shaft members;

Fig. 6 is a schematic plan view of shaft member embodiments applied to more than one cylinder;

Fig. 7 is a schematic perspective view of apparatus of a first embodiment;

Fig. 8 is a schematic perspective view of apparatus of a second embodiment; and

Fig. 9 is a schematic perspective view of apparatus of a third and fourth embodiment;

With reference to the drawings, and in particular Fig. 1, there is provided conventional apparatus of a four stroke internal combustion engine 10.

The conventional engine 10 comprises the known element of a cylinder 12 which houses a piston **M** which is movably sealed therein.

The piston **M** is attached to a crankshaft **P** by a connecting rod **N** and rod bearing **O**. The crankshaft **P** serves to convert the up and down motion of the piston **M** into rotational motion; which is utilised to turn wheels of a vehicle, propellers of a vessel or aircraft.

The conventional engine 10 also comprises the known element of a cylinder head **D** having an intake valve

assembly **A** and an exhaust valve assembly **J** which are both intermittently actuated by a camshaft **I**. Both valve assemblies **A**, **J** have rocker arms 14, 18 with corresponding springs 16, 20, and conventional poppet valves 22, 24.

On the intake stroke of a four stroke engine 10, the intake valve assembly **A** is open to allow an ingress of air/fuel mixture into the cylinder 12 via an intake port **C**.

Meanwhile, the exhaust valve assembly **J** is closed. The piston **M** will retract drawing the air/fuel mixture into the cylinder 12.

The piston **M** retracts by virtue of stored energy being transferred from a flywheel (not shown) to the piston **M** via the crankshaft **P**.

It should be understood that on all "non-power strokes", namely, retraction of the piston **M** on the intake stroke, compression of the air/fuel mixture, and exhausting of the combusted gases, the energy required to drive the piston **M** is transferred from the flywheel to the connected crankshaft **P**.

As the piston **M** bottoms out it will change direction and extend within the cylinder 12. Closure of the intake valve assembly **A** allows for the air/fuel mixture to be compressed within the cylinder 12; referred to as "compression stroke".

Again, the exhaust valve assembly J is closed.

When fully compressed, a spark plug K extending into the cylinder 12, ignites the compressed mixture to cause combustion.

Alternatively, in a diesel engine, the heat caused by compressing the air/fuel mixture alone will result in combustion.

The resultant combustion produces an excess of gases which force the piston M to retract within the cylinder 12.

The exhaust valve assembly J is opened as the piston M bottoms out to allow an egress of the combusted gases through an exhaust port L; referred to as "exhaust stroke".

As the piston M returns to an extended position, the exhaust valve assembly J is closed, whereas the intake valve assembly A is open to start the cycle again and allow in ingress of air/fuel mixture.

It will be realised that the timing of the opening and closing of the valve assemblies A, J will have a large bearing on the performance of the engine 10.

If either of the valve assemblies A, J are open on the compression stroke, then the air/fuel mixture will not be fully compressed resulting in poor performance of the engine 10.

Lobes or cams 26 located on the camshaft I are designed to intermittently open and close each of the valve assemblies A, J as and when required.

It will be realised however, that (fixed) cams 26 of a particular design operate optimally for a given range of speeds only.

The rocker arms 14, 18 act against the corresponding valves 22, 24 and valve return springs 20, 16. The valves 22, 24 are fired in one direction, only then to stop at the extent of their travel, and be sent flying in the opposite direction. This happens many times a minute which wastefully drains power from the engine 10 and can cause noise, vibration and harshness.

In a first embodiment of the present invention, as illustrated in Figs. 2a-d and Fig. 7, there is provided apparatus 100 in the form of a cylinder head assembly comprising a cylinder head D adapted with a valve assembly replacement shaft member 110 rotatably mounted.

The shaft member 110 is of the form of a cylindrical rod with a recess 112 removed around a portion of the circumference of the shaft member 110 and along that part of its length which is presented to (above) the cylinder 12.

It is to be understood that the shaft member 110 and recess 112 are presented facing the cylinder

irrespective of the cylinders orientation; for example, it may be a horizontal engine, in which case the recess 112 is presented adjacently facing the cylinder 12.

The shaft member 110 is rotatably mounted in the cylinder head D.

The shaft member 110 is parallel with, and is co-operatively driven by, the crankshaft P by virtue of connecting means (not shown) in the form of a belt or gearing 114.

The recess 112 serves to allow an ingress or egress of air/fuel mixture or exhaust gases to and from the cylinder 12 upon rotation of the shaft member 110.

The depth and length of the recess 112 presented to (above) the cylinder 12 can be of any design and dimensions to allow optimum ingress and/or egress of air/fuel mixture and/or combusted gases to and from the cylinder 12; for example, the recess 112 may be of uniform depth and length or may have varying depths or lengths, or the recess 112 may also be of the form of a helix, etc.

In operation, as shown in Fig. 2a and Fig. 7, there is an inlet of air from an inlet manifold 116 which is coupled to a carburettor/fuel injector (not shown) to form an air/fuel mixture.

The shaft member 110 is presented such that the recess 112 faces the intake port **C** and the cylinder 12 to allow an ingress of air/fuel mixture.

Rotation of the crankshaft **P**, initially caused by a starter motor (not shown) then subsequently by the transfer of energy from the flywheel, causes contra-rotation of the shaft member 110 by virtue of contra-connecting means (not shown) being connected to the crankshaft **P** and gearing 114 on the shaft member 110.

Rotation of the crankshaft **P** will cause the piston **M** to retract, drawing-in the air/fuel mixture through the inlet port **C**, into the cylinder 12.

Meanwhile, as the piston **M** is retracted by virtue of the rotating crankshaft **P**, the recess 112 of the shaft member 110 will contra-rotate in unison.

As the piston **M** bottoms out, the rotating shaft member 110 and recess 112 face the intake port **C** and the cylinder head **D**. Thus preventing any ingress or leakage of air/fuel mixture on the compression stroke, as shown in Fig. 2b.

On the compression stroke, the piston **M** is extended to compress the air/fuel mixture as the crankshaft **P** and interconnected shaft member 110 similarly rotate, as shown in Fig. 2c.

The recess 112 faces the cylinder head D and the exhaust port L.

A spark plug K (not shown for convenience in Figs. 2a-d), ignites the compressed air/fuel mixture in the cylinder 12.

Alternatively, in a diesel engine, the heat caused by compressing the air/fuel mixture alone will result in combusted gases.

The resultant combustion causes the piston M to be fired to a retracted position causing the crankshaft P and shaft member 110 to rotate.

The recess 112 meanwhile, will rotate facing both the exhaust port L and cylinder 12 to allow the piston M to extend exhausting the combusted gases out through the recess 112 into the exhaust port L.

Upon exhaustion of the combusted gases, rotation of the crankshaft P will cause the recess 112 to rotate and face the cylinder 12 and inlet port C to allow the cycle to begin again.

As the rotation of the crankshaft P and shaft member 112 are rotating opposite to one another, this will have a balancing effect which may reduce noise and vibration of the engine 10.

In a second embodiment of the present invention, as shown in Figs. 3a-d and Fig. 8, there is provided

apparatus 200 in the form of a cylinder head assembly comprising a cylinder head D having two valve assembly replacement shaft members, namely, an intake shaft member 210 and an exhaust shaft member 212 which are rotatably mounted.

The shaft members 210, 212 are of the form as described above with recesses 214, 216 as also described above.

The shaft members 210, 212 are rotatably mounted in the cylinder head D as before.

The shaft members 210, 212 are parallel with, and are co-operatively driven by, the crankshaft P by connecting means (not shown) coupled to gearing 114.

Alternatively, the shaft may be belt driven from the crankshaft P.

The recesses 214, 216 are as described above, and serve to allow an ingress of air/fuel mixture and an egress of combusted gases respectively, into the cylinder 12 upon rotation of the crankshaft P and shaft members 210, 212.

The depth and length of the recesses 214, 216 presented to (above) the cylinder 12 can be of any design and dimensions to allow optimum ingress and egress of air/fuel mixture and combusted gases to and from the cylinder 12; for example, the recesses 214, 216 may be of uniform depth and length or may

have varying depths or lengths, or they may be of the form of a helix, etc.

In operation, as shown in Fig. 3a, the intake shaft member 210 is rotated, by the crankshaft P, to face the intake port C and the cylinder 12 to allow an ingress of air/fuel mixture.

Meanwhile, the exhaust shaft member 212 faces the exhaust port L and cylinder head D thus preventing air/fuel mixture to leave the cylinder 12 or air to enter therein.

As the air/fuel mixture enters the cylinder 12 from the intake port C, the crankshaft P rotates causing the piston M to retract, causing the shaft members 210, 212 and hence recesses 214, 216, to rotate in unison by virtue of them being interconnected by connecting means to the gearing 114.

As the piston M begins to extend, the recess 214 rotates to face the cylinder 12 and cylinder head D. Thus preventing any ingress or leakage of air/fuel mixture from the cylinder 12 on the compression stroke, as shown in Fig. 3b.

Meanwhile, the exhaust shaft member 212 will likewise have rotated with the recess 216 now facing the cylinder head D completely. Thus preventing an ingress of air or an egress of air/fuel mixture.

On the compression stroke, the crankshaft P rotates causing the piston M to extend compressing the air/fuel mixture. The interconnected shaft members 210, 212 and recesses 214, 216 similarly rotate.

As the piston M becomes fully extended on the compression stroke, the intake recess 214 at this point completely faces the cylinder head D and is thus closed off preventing any egress of compressed air/fuel mixture, as shown in Fig. 3c.

A spark plug K (not shown for convenience in Figs. 3a-d), ignites the compressed air/fuel mixture in the cylinder 12.

Alternatively, in a diesel engine, the heat caused by compressing the air/fuel mixture alone will result in combustion.

The resultant combustion causes the piston M to be fired to a retracted position causing the crankshaft P and shaft members 210, 212 to rotate.

The intake recess 214 will rotate facing both the cylinder head D and the intake port C.

The exhaust recess 216 will rotate facing the cylinder 12 and exhaust port L to allow an egress of combusted gases, as shown in Fig. 3d.

The piston **M** then extends exhausting the combusted gases out through the recess 216 into the exhaust port **L** by virtue of the rotating crankshaft.

Meanwhile, rotation of the crankshaft **P** will cause the intake recess 214 to rotate and face the inlet port **C** and the cylinder 12 to allow the cycle to begin again.

The exhaust recess 216 will likewise rotate facing the exhaust port **L** and the cylinder head **D**, as shown in Fig. 3a.

In a third embodiment of the present invention there is provided apparatus 400, as shown in Figs. 5 and 9, having apparatus 200 as previously described in the second embodiment, wherein the intake shaft member 210 and the exhaust shaft member 212 are of the form of a hollow cylindrical intake shaft member 410 and a hollow cylindrical exhaust shaft member 412.

In this way, it should be realised that the heavy intake manifold (not shown) and outlet manifold 116, can be replaced by single, less heavy and complicated manifolds 418, 420, which allow the ingress of air/fuel mixture and egress of combusted gases through the hollow shaft members 410, 412.

The shaft members 410, 412 are presented to (above) the cylinder 12 to allow an ingress of air/fuel mixture thereto through aperture 414, and an egress

of exhaust gases therefrom through aperture 416.

In this third embodiment, the air/fuel mixture passes through the hollow intake shaft member 410 and exits through the aperture 414 into the cylinder 12.

After the compression and combustion strokes, the exhaust gases exit the cylinder 12 through the aperture 416 and leave via the hollow exhaust shaft member 412.

The shaft members 410, 412 are connected to the crankshaft P by connection means (not shown) coupled to gearing 114.

Alternatively, the shaft members 410, 412 may be coupled to the crankshaft P by a belt.

It is conceived that rotation of the shaft members 410, 412 although specifically described as being coupled to and controlled by the crankshaft P, may be independently controllable adjustable.

Furthermore, both shaft members 410, 412 may be driven independently from the crankshaft P and of each other.

In a fourth embodiment of the present invention, there is provided apparatus 200 wherein the shaft members 210, 212 are of the form of hollow shaft members 300, as shown in Figs. 4a and 4b.

Each shaft member 300 has an inner hollow cylindrical tube 310, rotatably mounted within an outer hollow cylindrical tube 312, also rotatably mounted.

The tubes 310, 312 have apertures 314, 316 which correspondingly serve to allow an ingress of air/fuel mixture and egress of exhaust gases to pass therethrough.

The apertures 314, 316, when appropriately aligned, form a passage 326.
The area of the passage 326 is adjusted and controlled by the speed of rotation of the tubes 310, 312 relative to one another.

Rotation of the tubes 310, 312 is controlled by gears 318, 320 located around the circumference of a cylindrical buttressed end 322 of the tubes 310, 312.

Rotation of the tubes 310, 312 may be coupled to the crankshaft P with independently controllable/ adjustable means for varying the speed of rotation of the tubes 310, 312.

Alternatively, both tubes 310, 312 may be driven independently from the crankshaft P and of each other, with controllable/ adjustable means for varying the speed of rotation of the tubes 310, 312.

It will be recognised that the tubes 310, 312 may

also be belt driven or the such like, independently, or coupled to, the crankshaft P.

The speed of rotation of the inner tube 310, relative to the outer tube 312, is such that the area of the passage 326 maximises or restricts the rate of ingress or egress of air/fuel mixture or exhaust gases. In this way, the rotatable shaft members 300 offer a variable valve timing and variable valve size.

With reference to Figs. 4a and 4b, it is to be understood that both tubes 310, 312 do not move horizontally/longitudinally. The apertures 314, 316 share a common centre-line C/L, and are shown offset for illustrative purposes only.

Common to all embodiments and with regard to sealing of the various shaft members 110, 210, 212, 310, 312, 410, 412 of the present invention, these will be as tight a fit as possible cognisant of the expansion of materials of the individual, respective, components that will occur once the engine reaches working temperature.

The shaft members 110, 210, 212, 310, 312, 410, 412 include gas tight seals (not shown) incorporated on the outside faces of bearing races (not shown), of support bearings (not shown), that will be spaced along the rotating shaft members 110, 210, 212, 310, 312, 410, 412 between the cylinder 12.

Gas tight paddles (not shown) are located within apertures (not shown) of the shaft members 110, 210, 212, 310, 312, 410, 412, at either side of the respective recesses and apertures 112, 214, 216, 314, 316, 414, 416, of the axis of rotation.

Springs (not shown) are located at the base of the paddles within the apertures. These serve to force the paddles outwards towards and against the inside surfaces of the cylinder head p, within which the shaft members rotate, so ensuring a gas tight seal in a similar way to the WANKEL rotary engine.

Common to all embodiments, it should be realised that the shaft members 110, 210, 212, 310, 312, 410, 412 may be of the form of extended or adapted shaft members 510, 512, rotatably mounted, with a plurality of recesses or apertures 514, 516 corresponding to the number of cylinders 12, as shown in Fig. 6.

Furthermore, the recesses 112, 214, 216 and apertures 314, 316, 414, 416 of the corresponding shaft members 110, 210, 212, 310, 312, 410, 412 can be as wide as the diameter of the cylinder 12 above which they sit. This means that a far greater area will be available for an ingress of air/fuel mixture or egress of exhausted gases, than might be associated with conventional valves.

The hollow intake shaft members (310, 312,) 410, 510 may form an integral part of an inlet system (not

shown), or may feed into, much simplified, single branch manifolds 418, at the respective open end of the shaft members (310, 312), 410, 510 at an end of the cylinder head D.

The hollow exhaust shaft members (310, 312), 412, 512 may form an integral part of an exhaust system (not shown), or may feed into, much simplified, single branch manifolds 420, at respective open ends of the shaft members (310, 312), 412, 512 at an end of the cylinder head D.

In this way, the air/fuel mixture and exhaust gases would not be required to travel via individual openings within the cylinder head D to individual, heavy, complicated, and expensive multiple branches of intake/exhaust manifolds, feeding the intake/exhaust ports C, L to each cylinder 12.

The present invention as described, has a reduced size compared to a conventional engine 10 and offers greater flexibility to the location, installation, and utilisation of internal combustion engines.

The simpler design will have favourable implications as to complexity, overall size of the engine, efficiency, noise and reliability, finance of raw materials, manufacturing, etc.

For the sake of clarity, it should be understood that fuel injectors/carburettors, and the spark plug, have been omitted from Figs. 2a-d and 3a-d but

may be part of the cylinder head assembly.

Modifications and improvements may be made to the above without departing from the scope of the present invention.

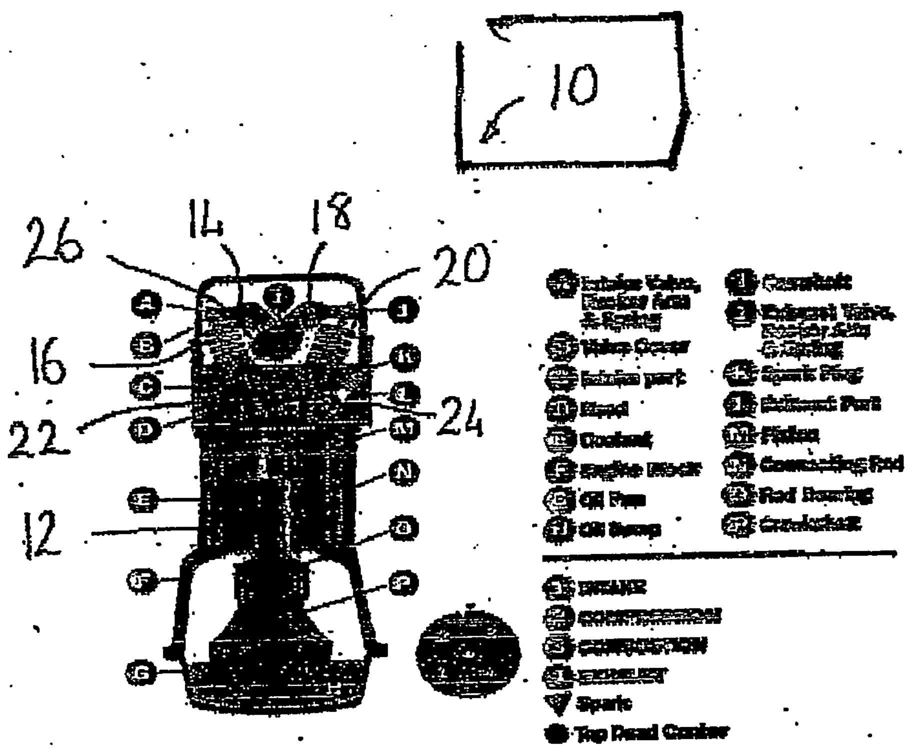

Fig. 1

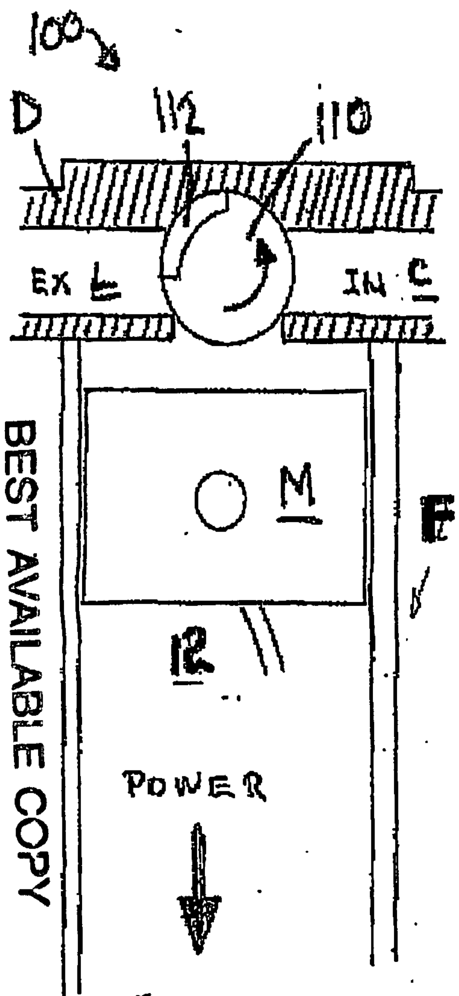

Fig. 2c

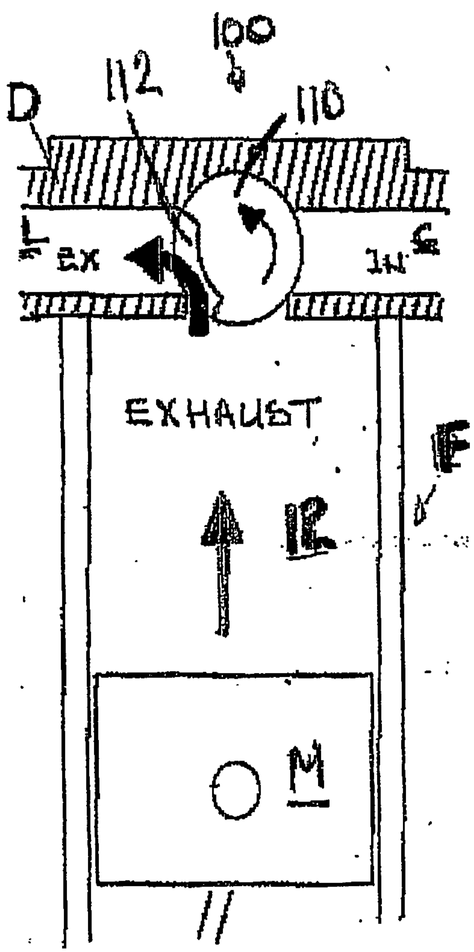

Fig. 2d

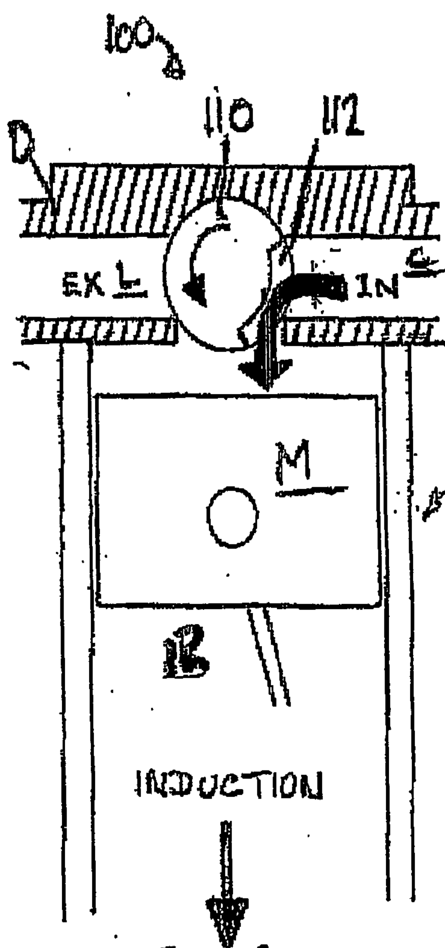

Fig. 2a

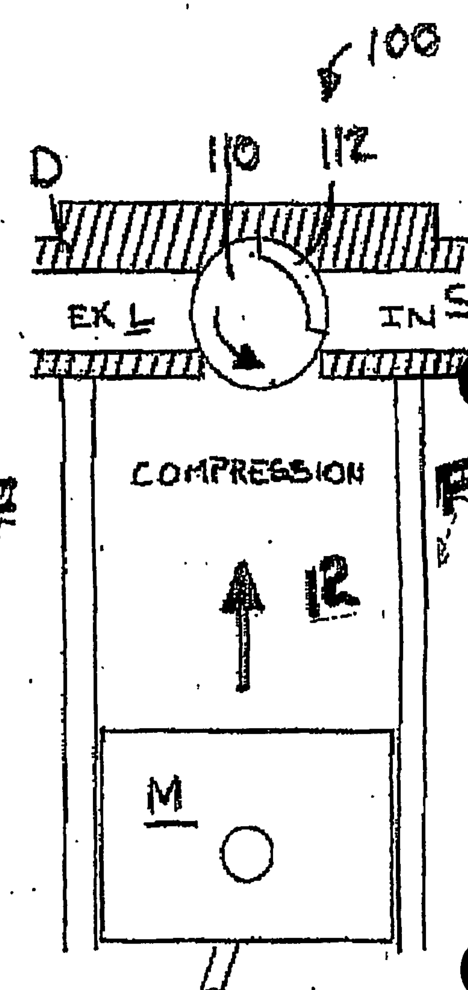

Fig. 2b

KEY:

DIRECTION of [CONTRA-] ROTATION

SCALLOP TAKEN OUT of SHAFT

TOTAL EXTENT of CYLINDER HEAD

IN INLET MANIFOLD

EX EXHAUST/EXIT MANIFOLD

DIAGRAM - NOT TO SCALE

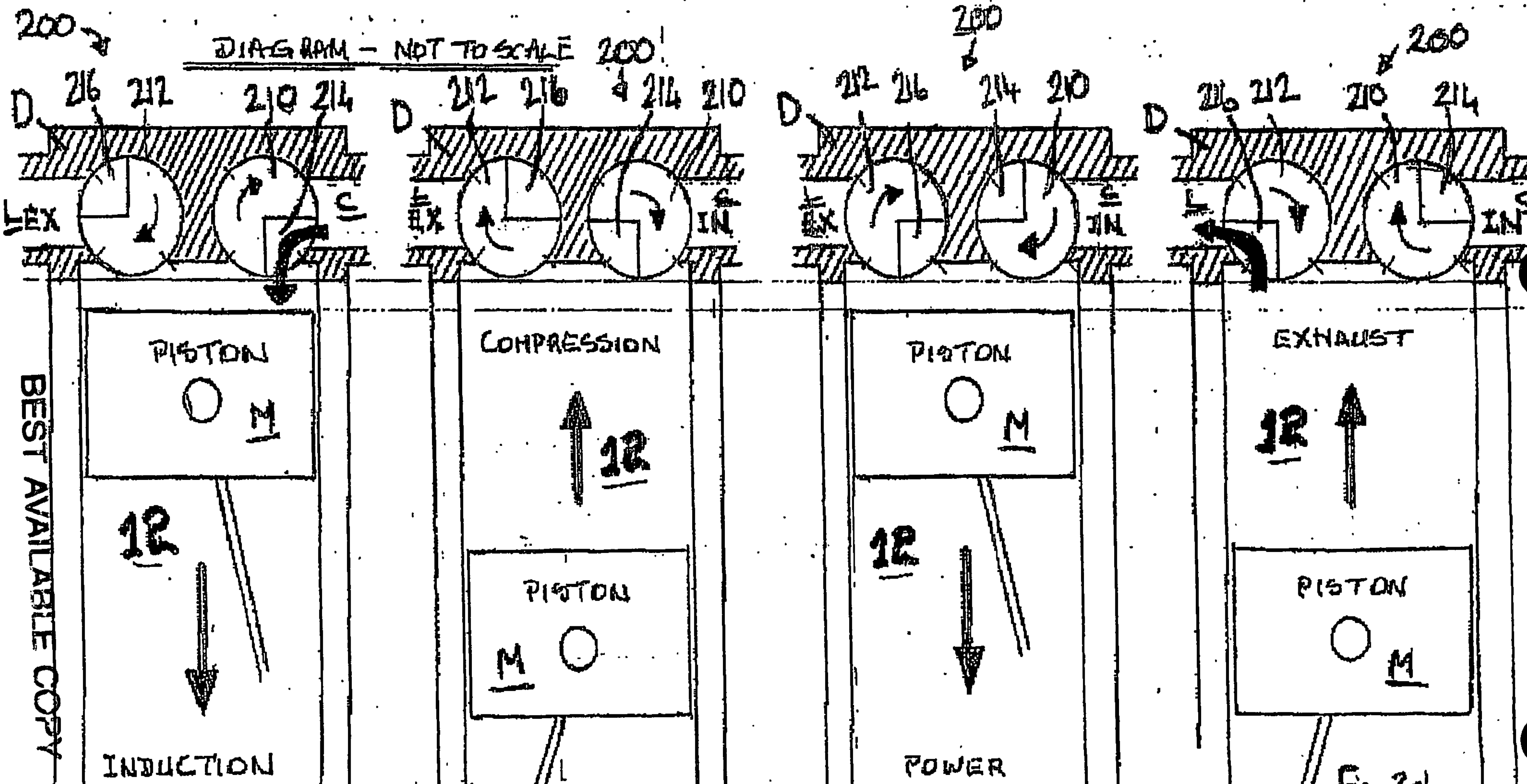

Fig. 3a

Fig. 3b

Fig. 3c

Fig. 3d

NOTE = PISTON NOT SHOWN AT COMPLETE TDC/BDC, SO AS TO SHOW ABOVE "OVERLAP" POSSIBLE TO ALLOW SUFFICIENT AIR/EXHAUST GASSES TO ENTER/LEAVE CYLINDER.

KEY =

DIRECTION of SHAFT ROTATION

SCALLOP TAKEN OUT of SHAFT

TOTAL EXTENT of CYLINDER HEAD

IN: INLET MANIFOLD

EX: EXIT MANIFOLD

BEST AVAILABLE COPY

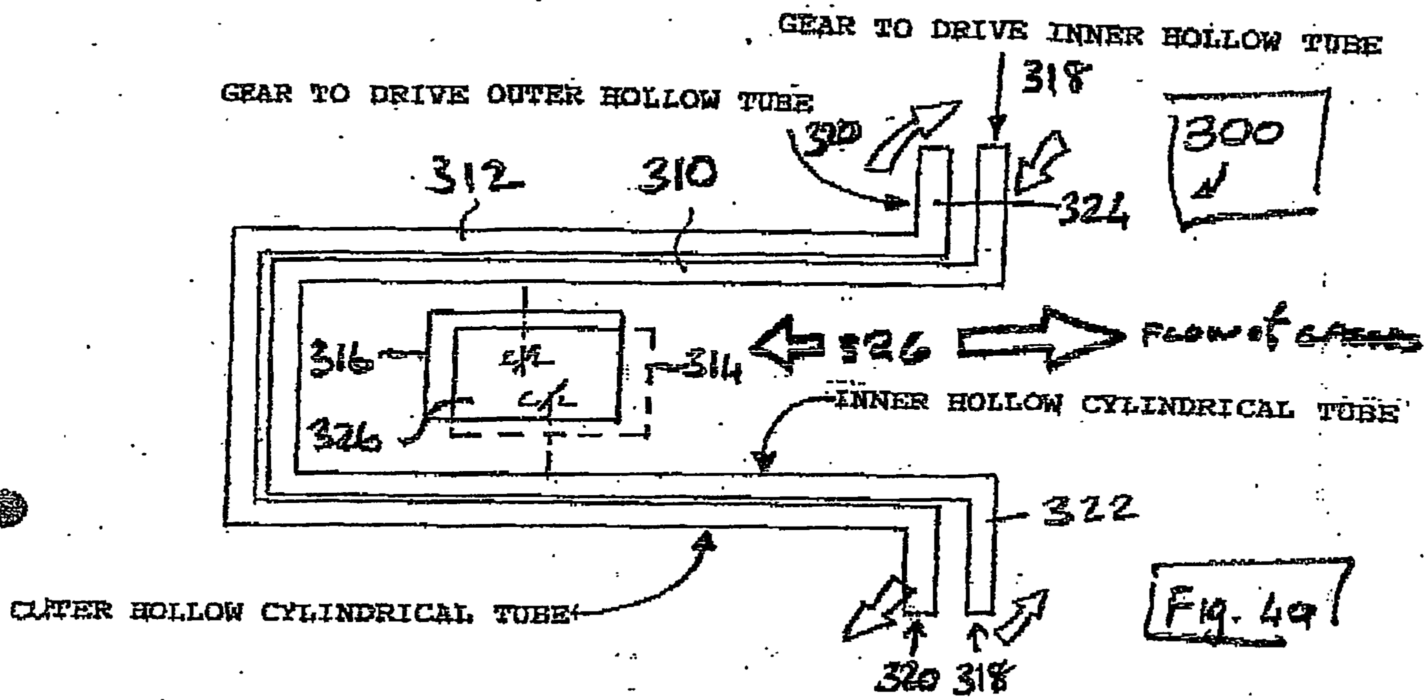
GEAR TO DRIVE INNER HOLLOW TUBE
318
GEAR TO DRIVE OUTER HOLLOW TUBE
300
320
312
310
324
316
314
326
326
FLOW of GASES
INNER HOLLOW CYLINDRICAL TUBE
322
OUTER HOLLOW CYLINDRICAL TUBE
320 318

Fig. 4a

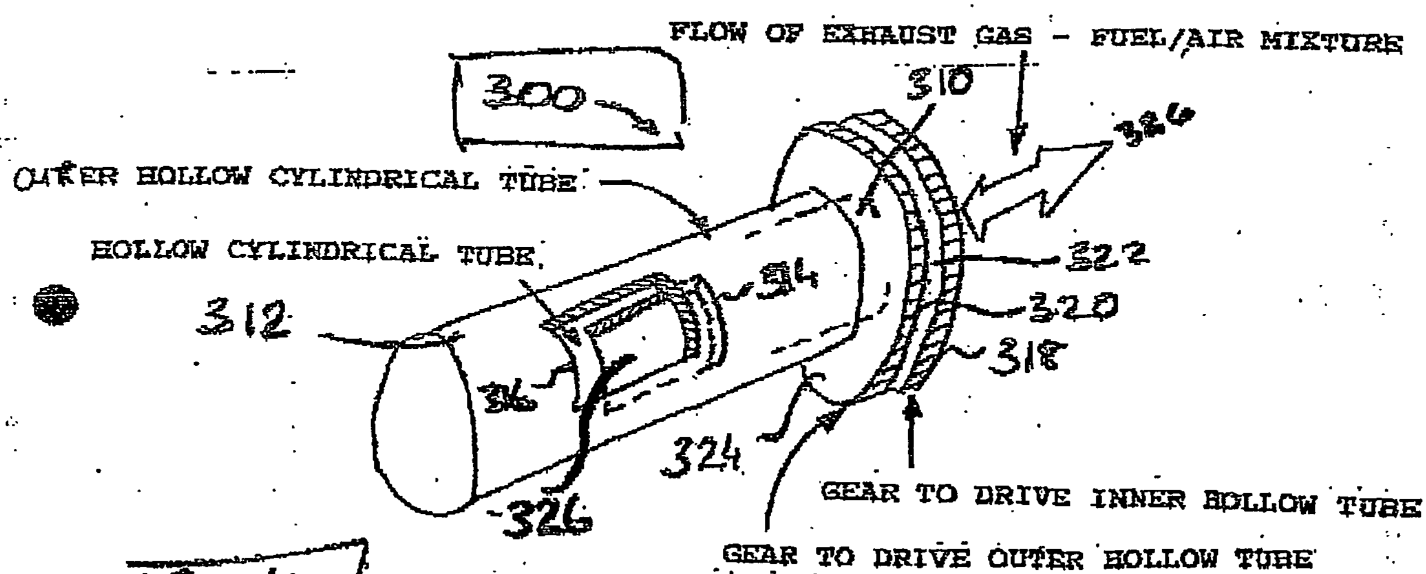
FLOW OF EXHAUST GAS - FUEL/AIR MIXTURE
300
310
324
OUTER HOLLOW CYLINDRICAL TUBE
HOLLOW CYLINDRICAL TUBE
322
314
312
320
318
316
324
326
GEAR TO DRIVE INNER HOLLOW TUBE
GEAR TO DRIVE OUTER HOLLOW TUBE

Fig. 4b

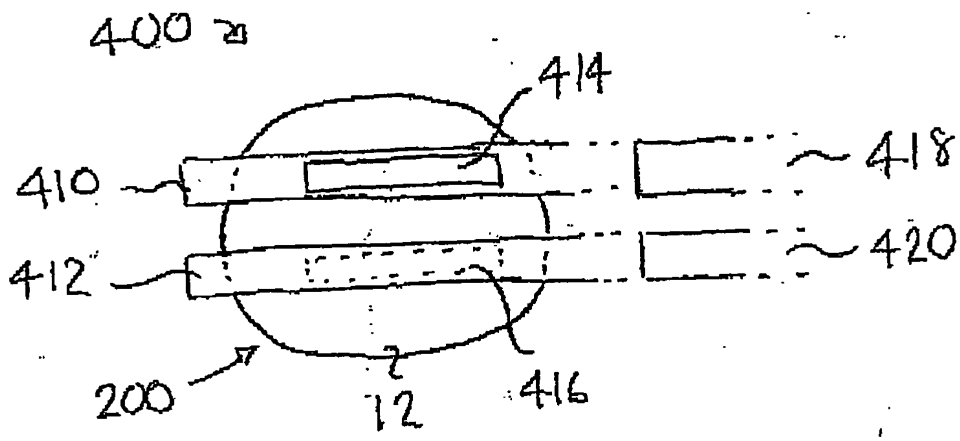
400
414
418
410
420
412
200
12
416

Fig. 5

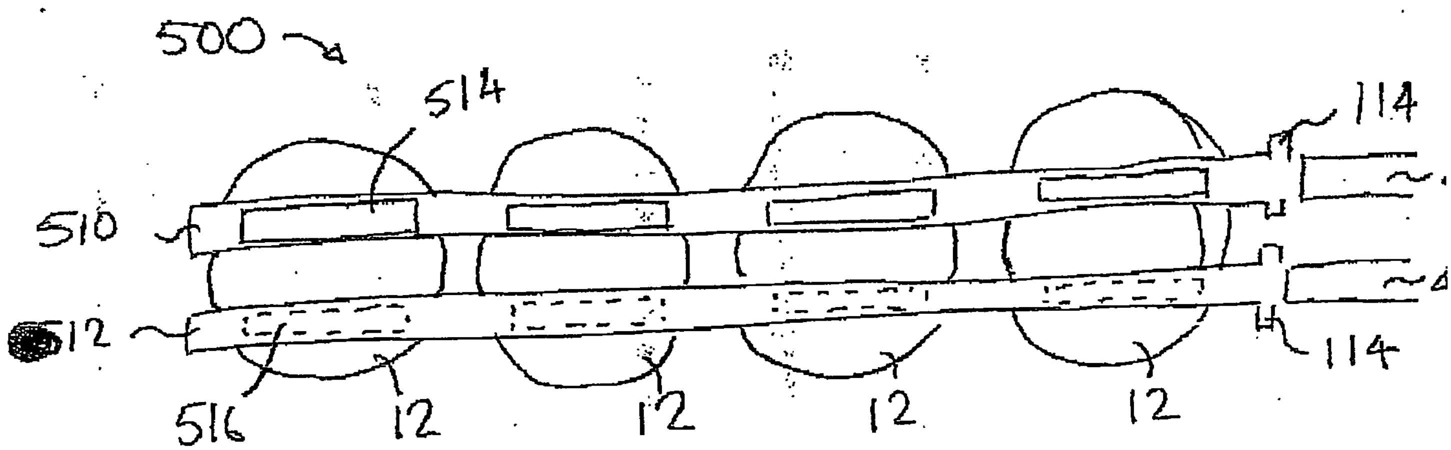
500
514
114
510
512
114
516
12
12
12
12

Fig. 6

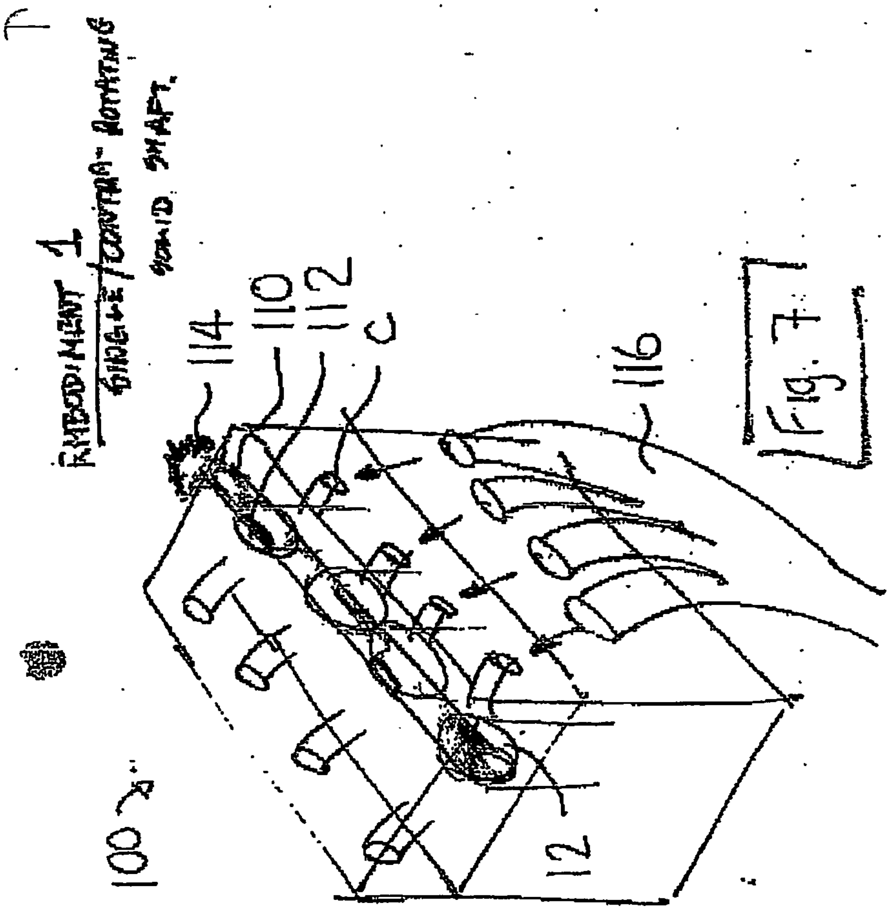

Fig. 7

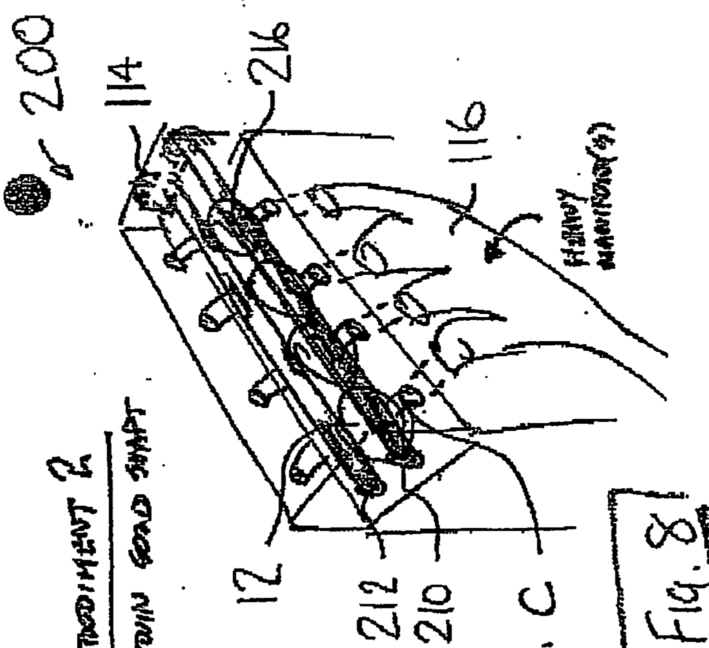

Fig. 8

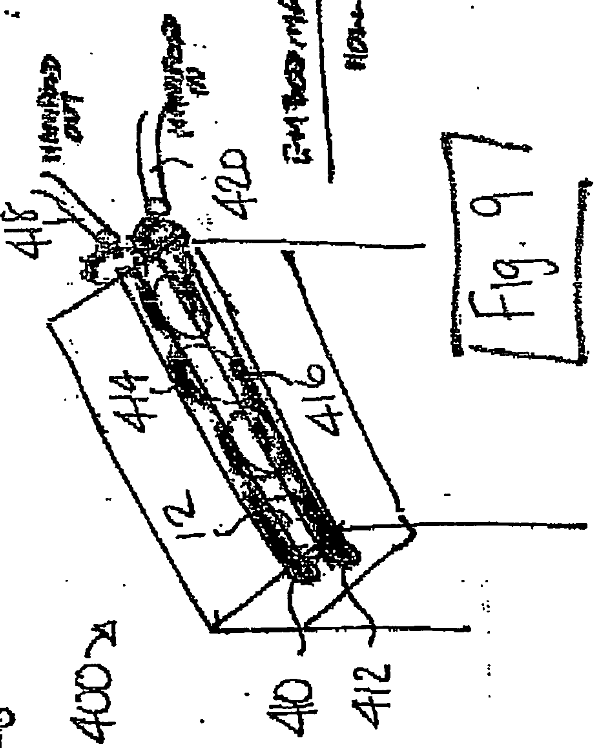

Fig. 9

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